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Yarita et al.

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[45] **Date of Patent: Oct. 23, 1990**

[54] **METHOD OF MANUFACTURING DOUBLE-SIDED WIRING SUBSTRATE**

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[73] Assignee: **Casio Computer Co., Ltd.,** Tokyo, Japan

[21] Appl. No.: **464,410**

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[30] **Foreign Application Priority Data**

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Jan. 30, 1989	[JP]	Japan	1-20623

[51] **Int. Cl.**^{5} **B44C 1/22;** C23F 1/02; C03C 15/00; C03C 25/06

[52] **U.S. Cl.** **156/645;** 29/852; 156/656; 156/661.1; 156/902; 427/97; 204/38.4

[58] **Field of Search** 156/643, 645, 652, 656, 156/659.1, 661.1, 666, 901, 902; 29/846, 852; 427/97; 174/68.5; 204/38.4

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Primary Examiner—William A. Powell

Attorney, Agent, or Firm—Frishauf, Holtz, Goodman & Woodward

[57] **ABSTRACT**

Disclosed is a method of manufacturing a double-sided wiring substrate wherein wiring patterns having a low resistivity are formed on both surfaces of a substrate. A pin hole is formed in a thin insulating film having excellent durability by a pin. A thin metal film is formed on the upper and lower surfaces of the insulating film and the inner wall of the pin hole by vacuum deposition. A thick metal film is formed on the entire thin metal film by electroplating. Thereafter, portions of the thin and the thick metal films formed on the upper and lower surfaces of the insulating film are etched while leaving a portion of them on the inner wall of the pin hole. Conductive patterns each having a layered structure of the thin and the thick metal films are thus formed on the upper and lower surfaces of the substrate.

5 Claims, 8 Drawing Sheets

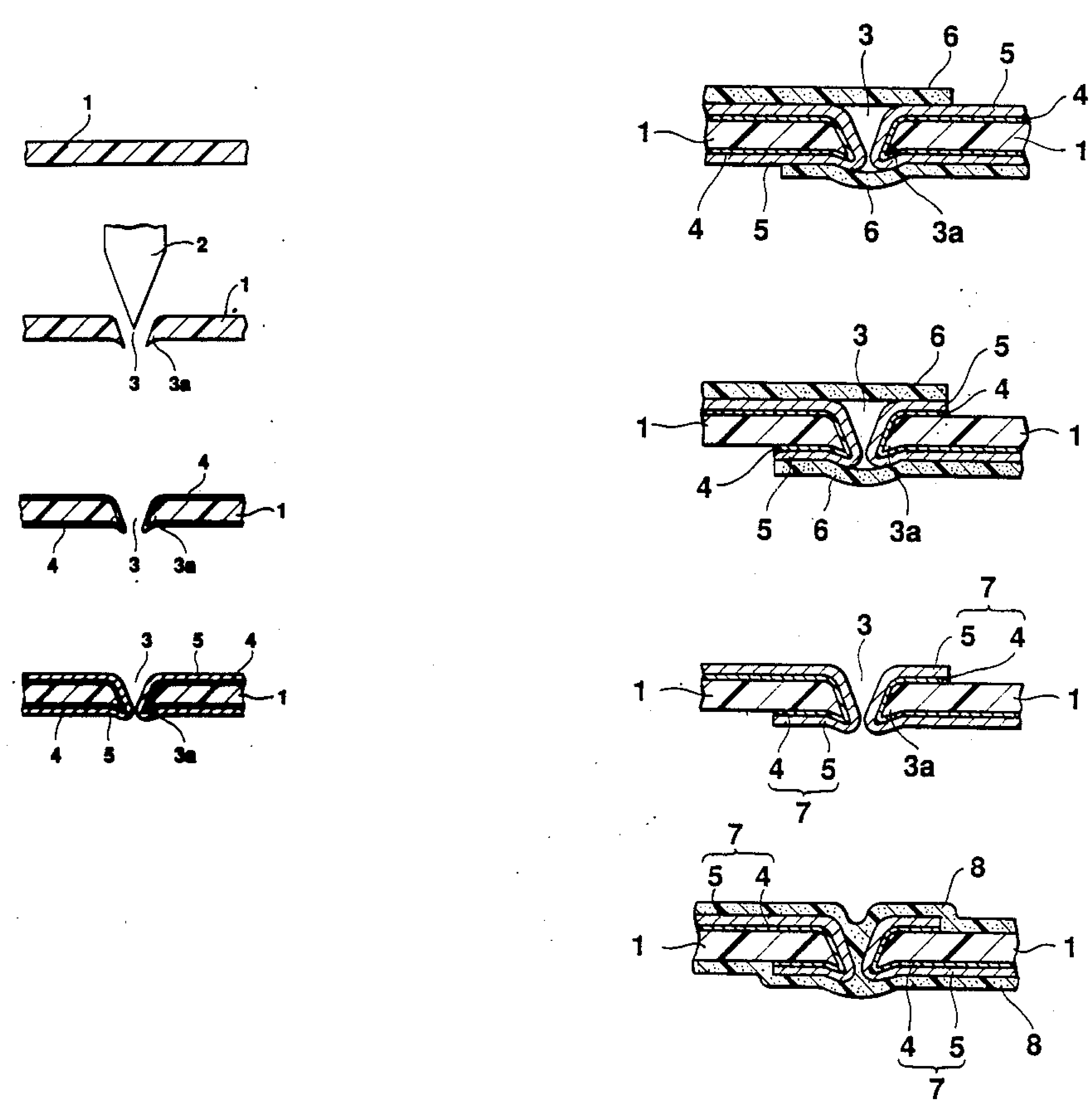


FIG.1 A

FIG.1 B

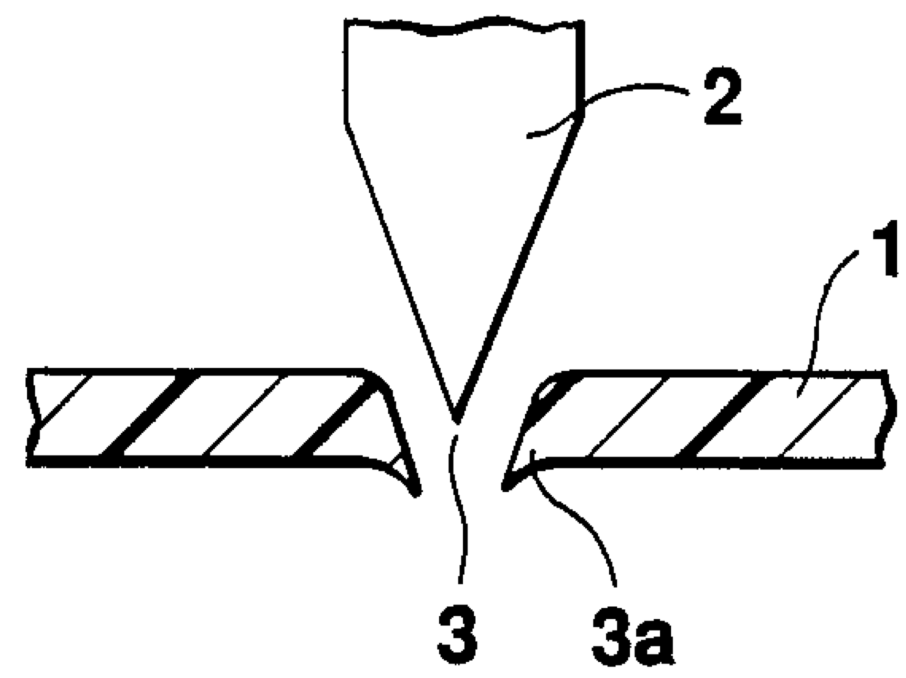


FIG.1 C

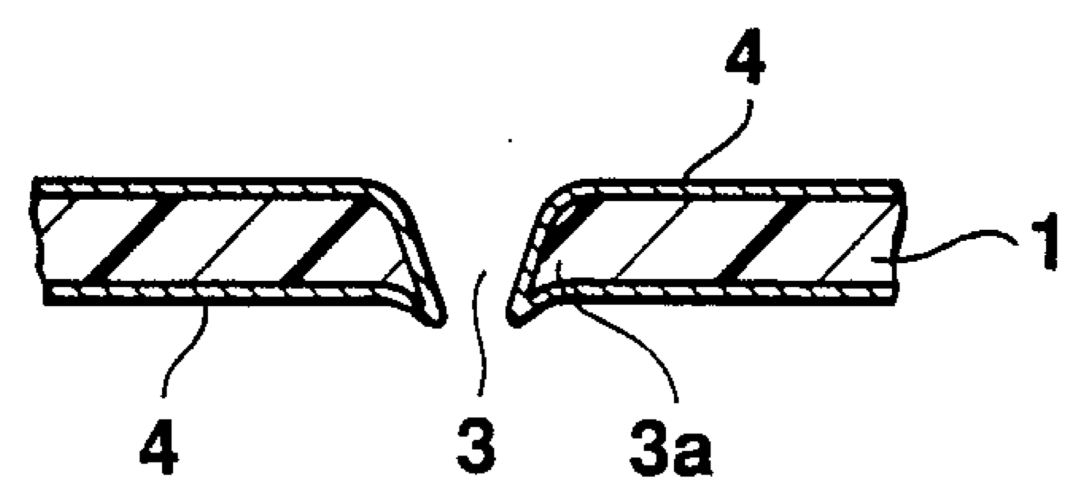


FIG.1 D

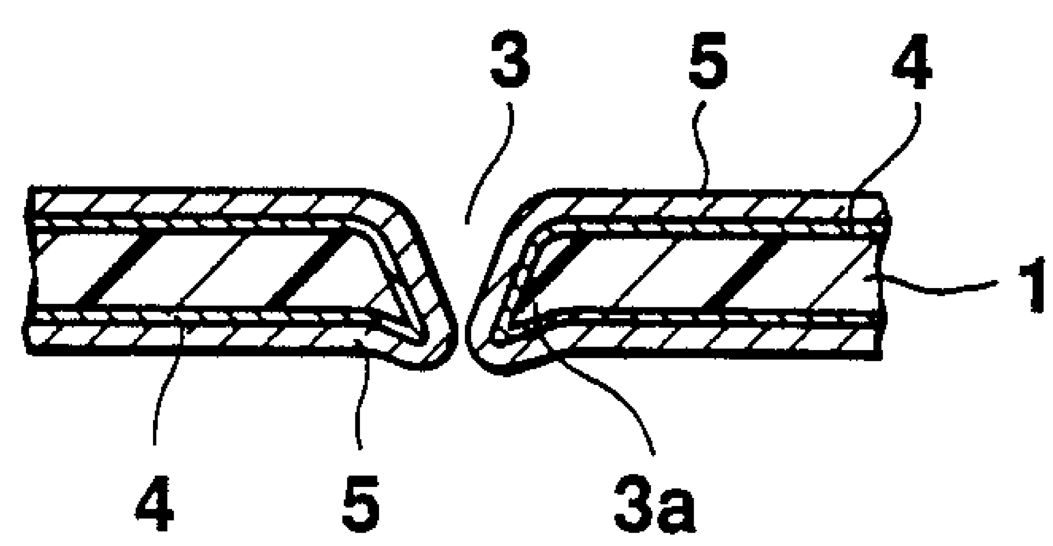


FIG. 1E

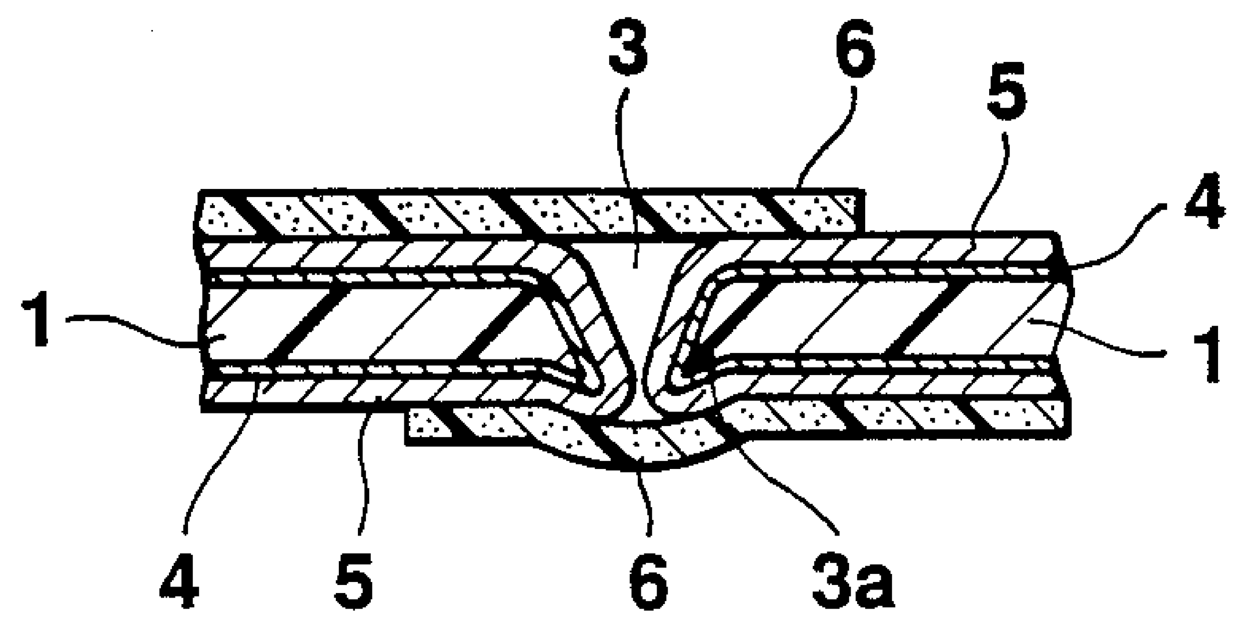


FIG. 1F

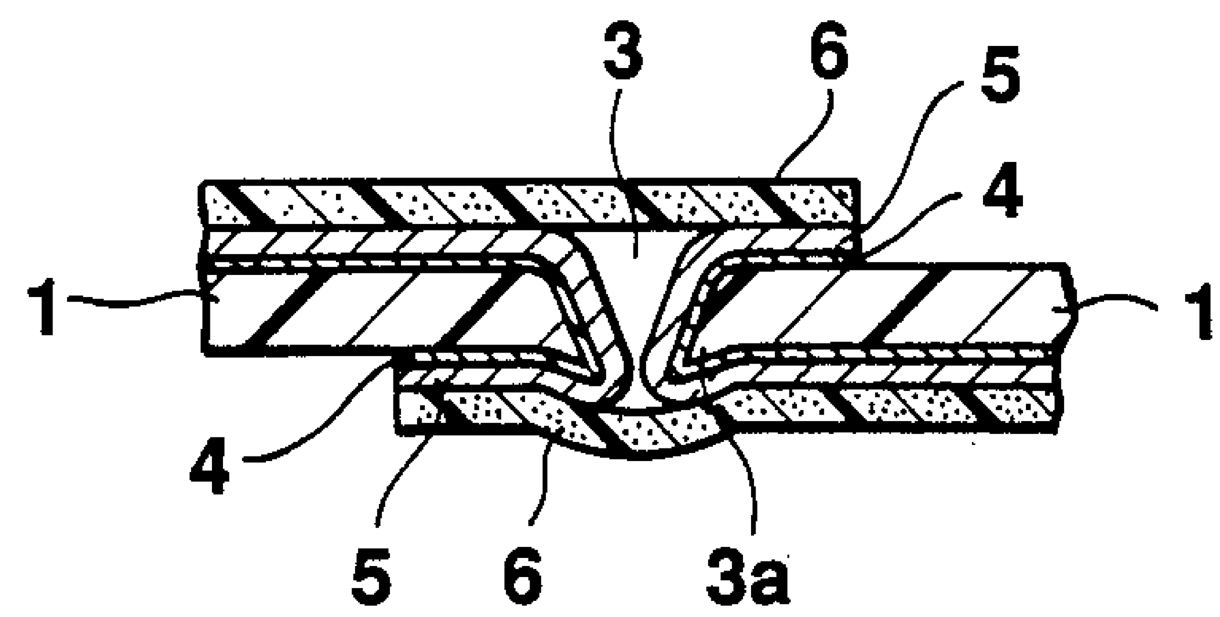


FIG. 1G

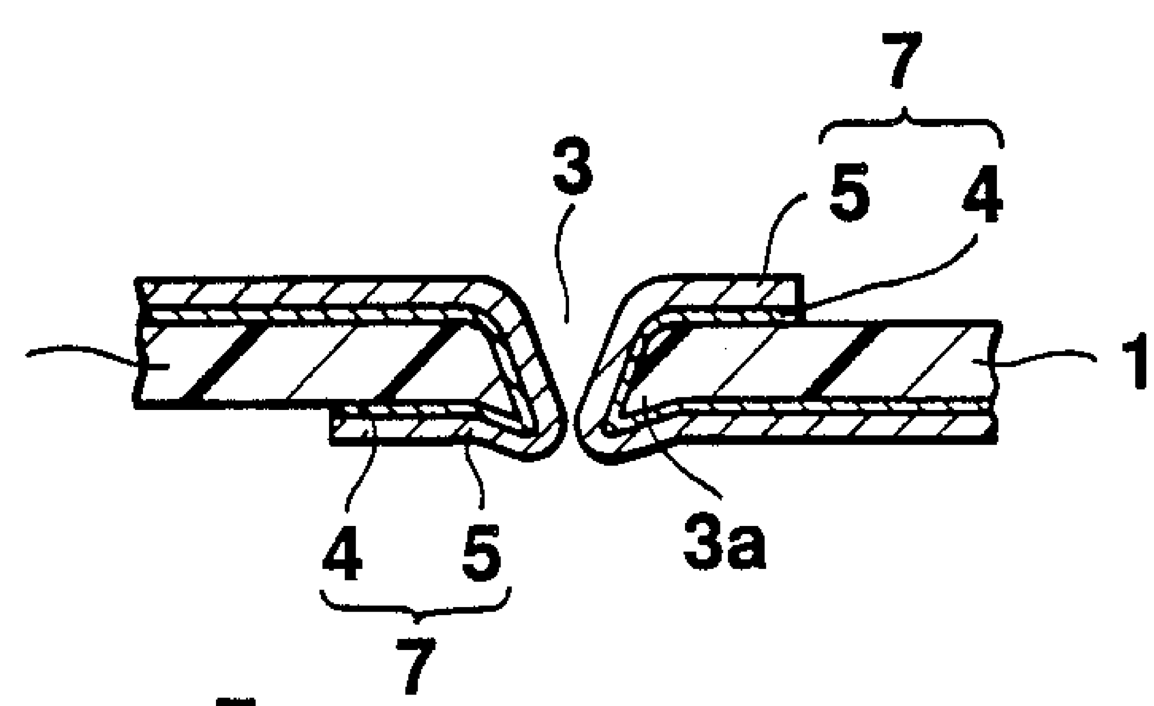


FIG. 1H

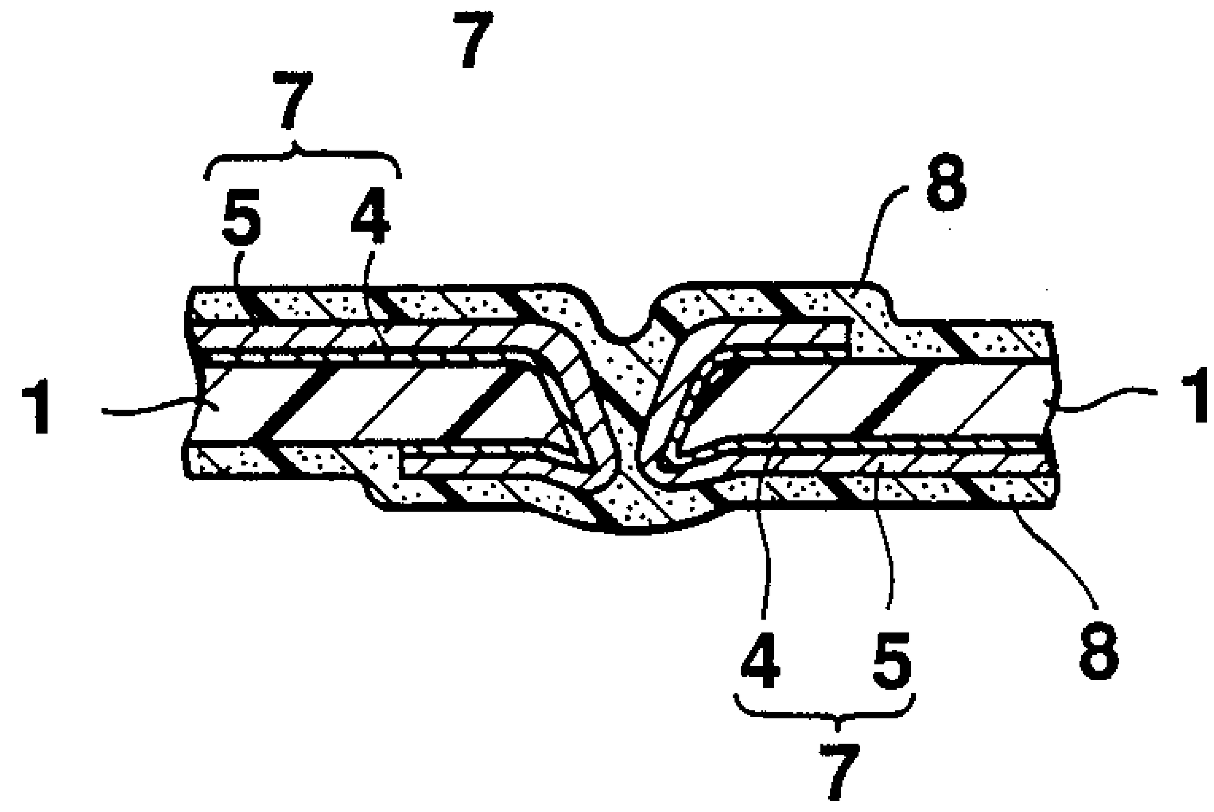


FIG.2 A

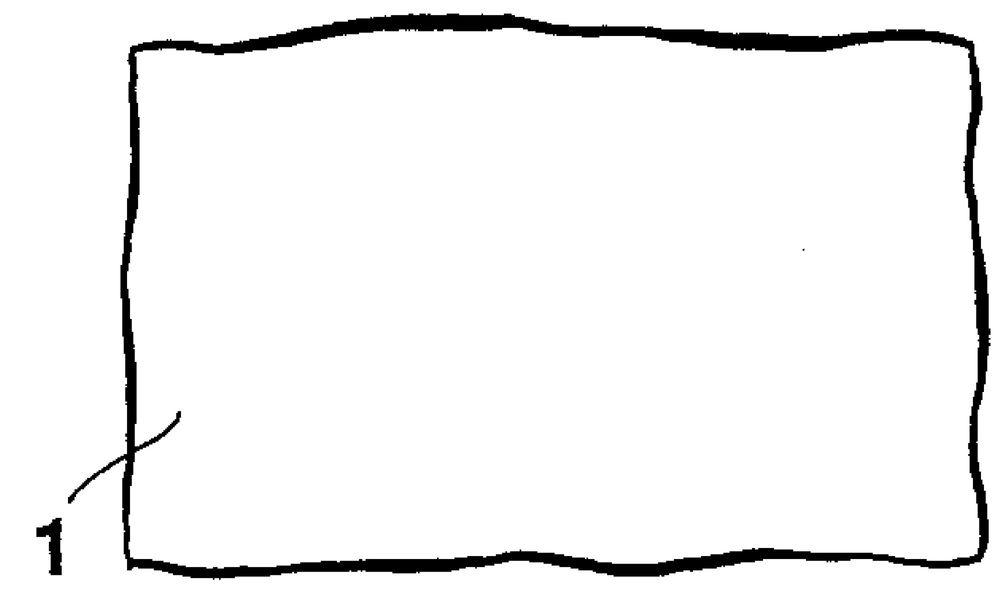


FIG.2 B

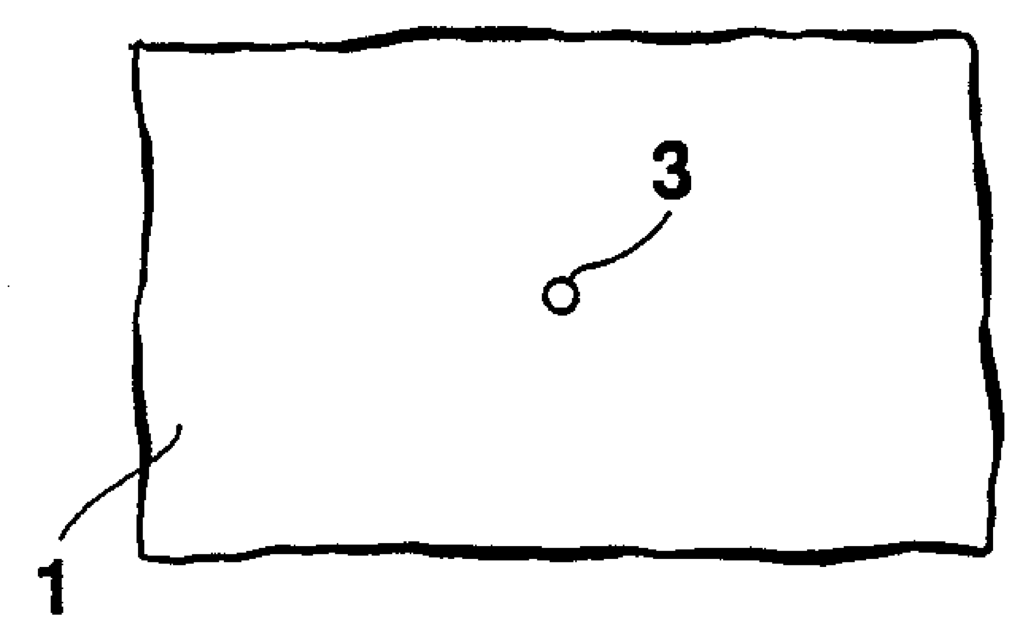


FIG.2 C

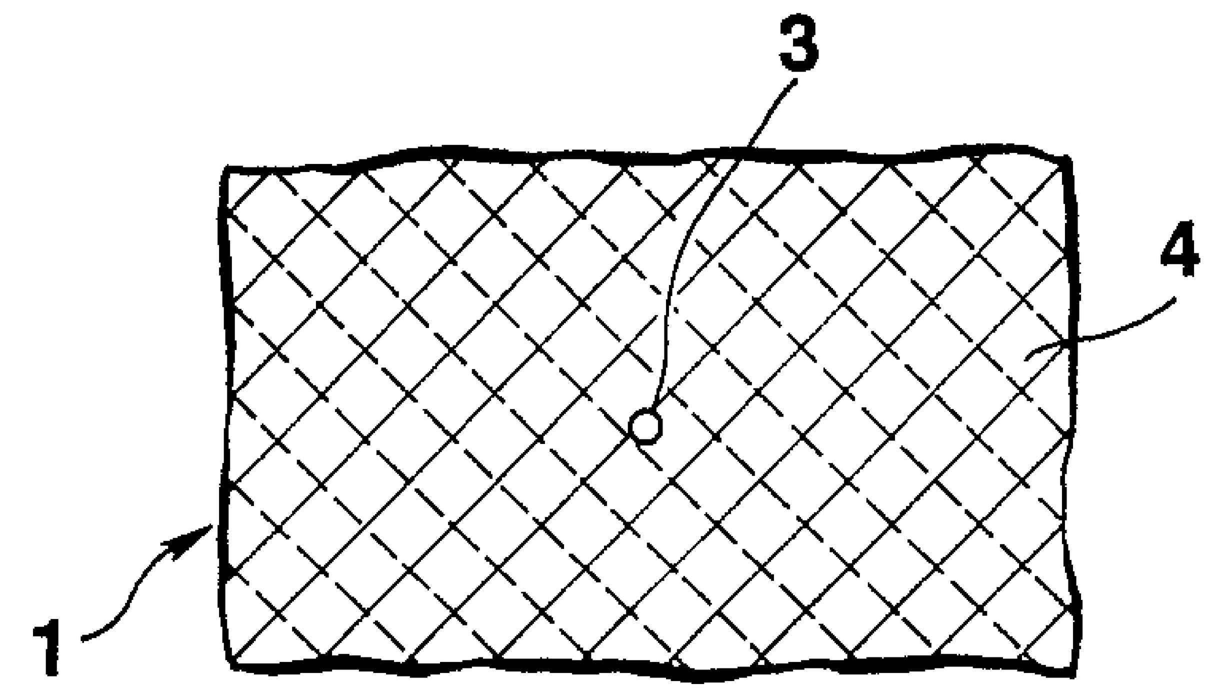


FIG.2 D

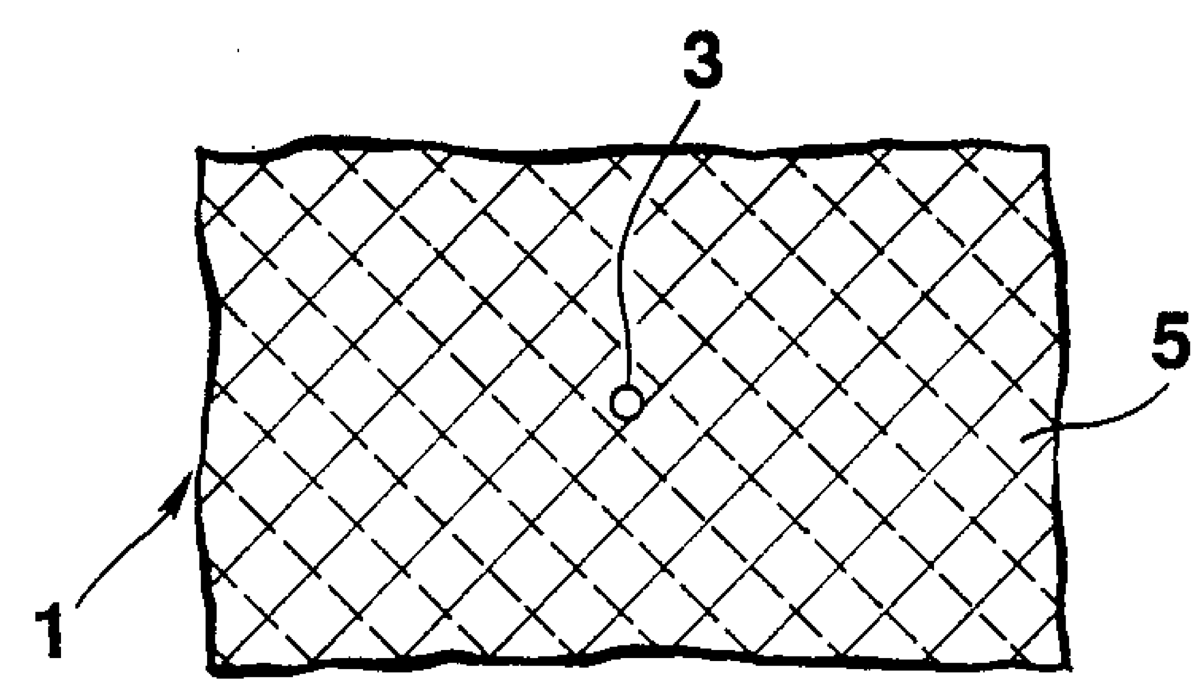


FIG. 2 E

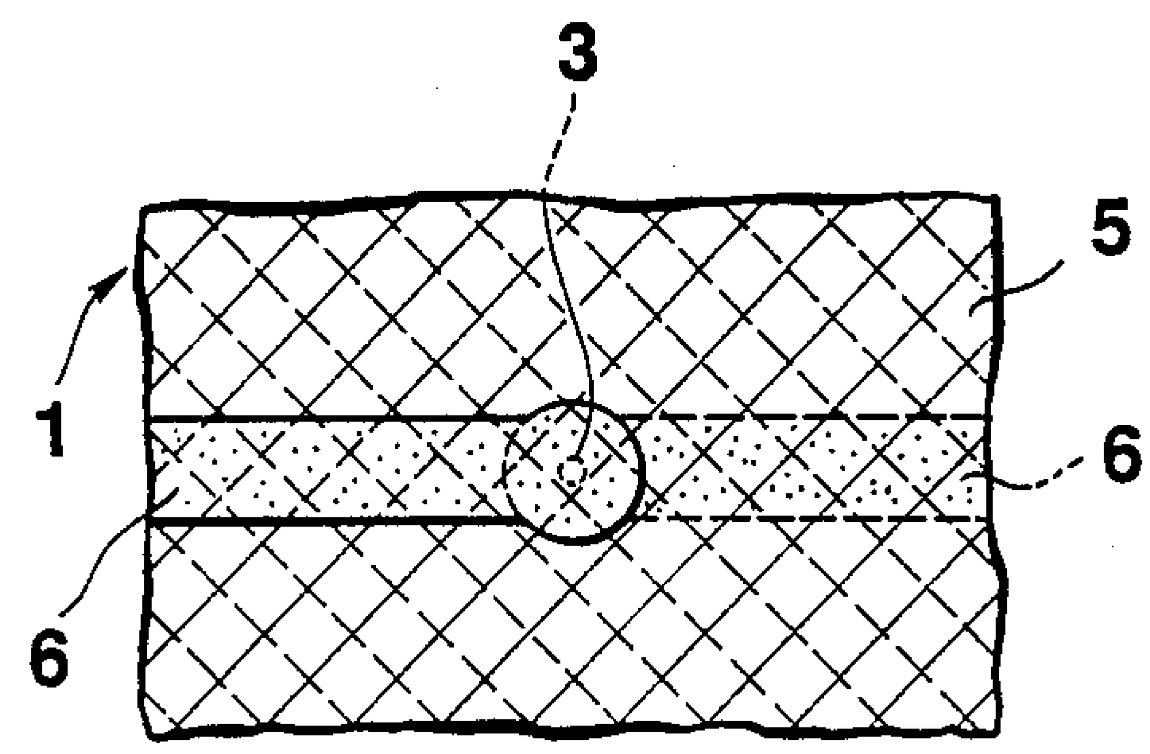


FIG. 2 F

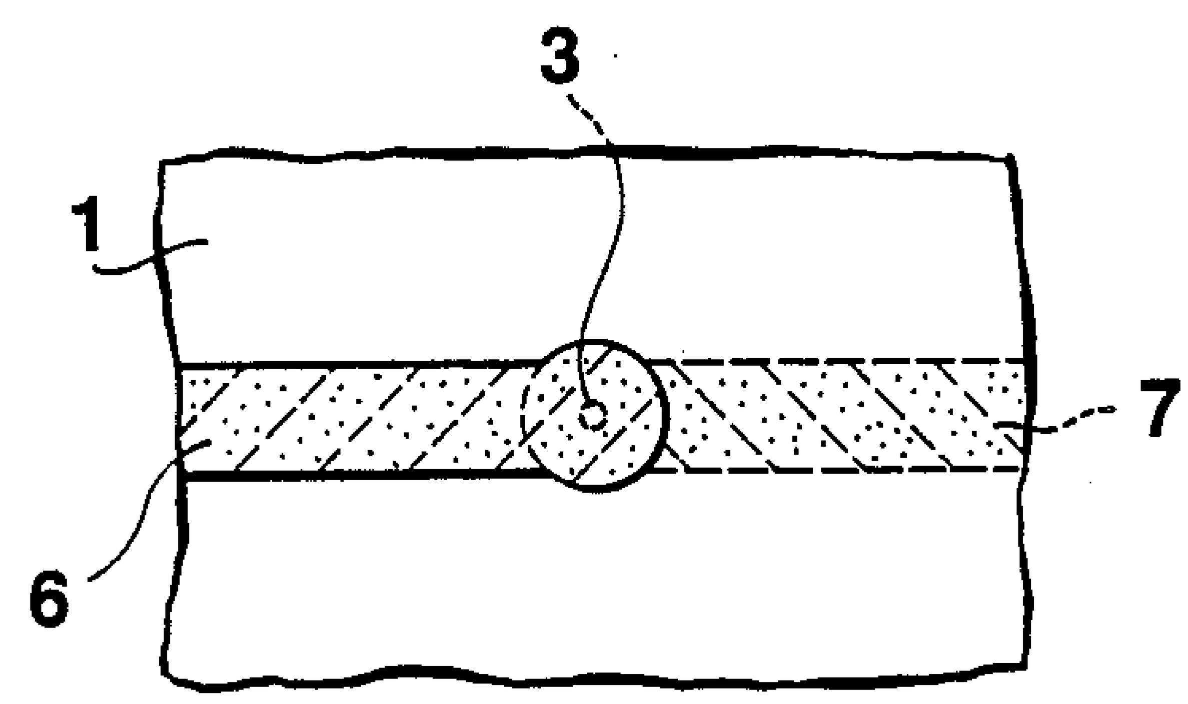


FIG. 2 G

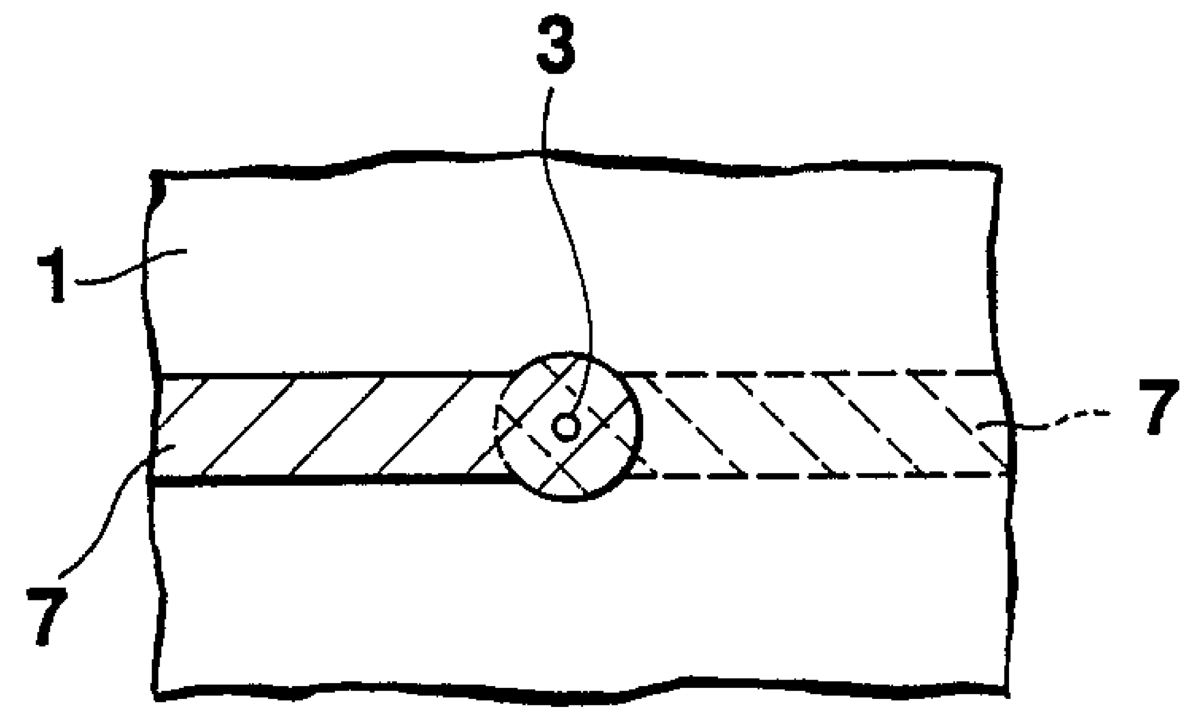
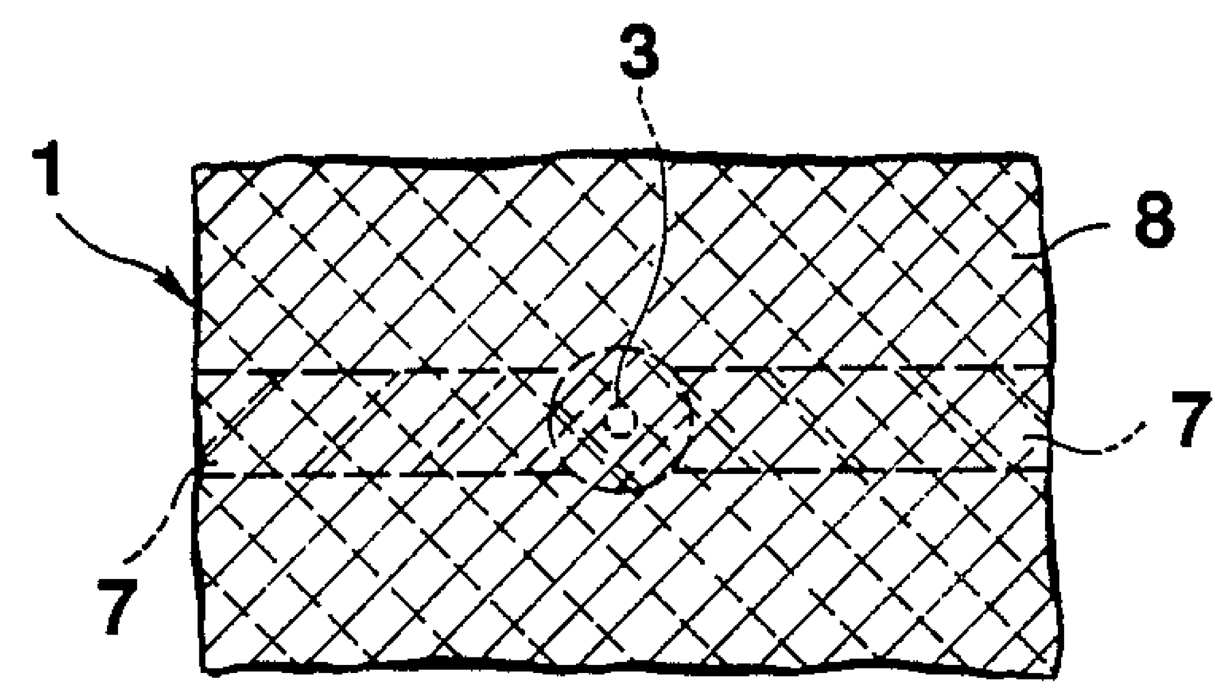


FIG. 2 H



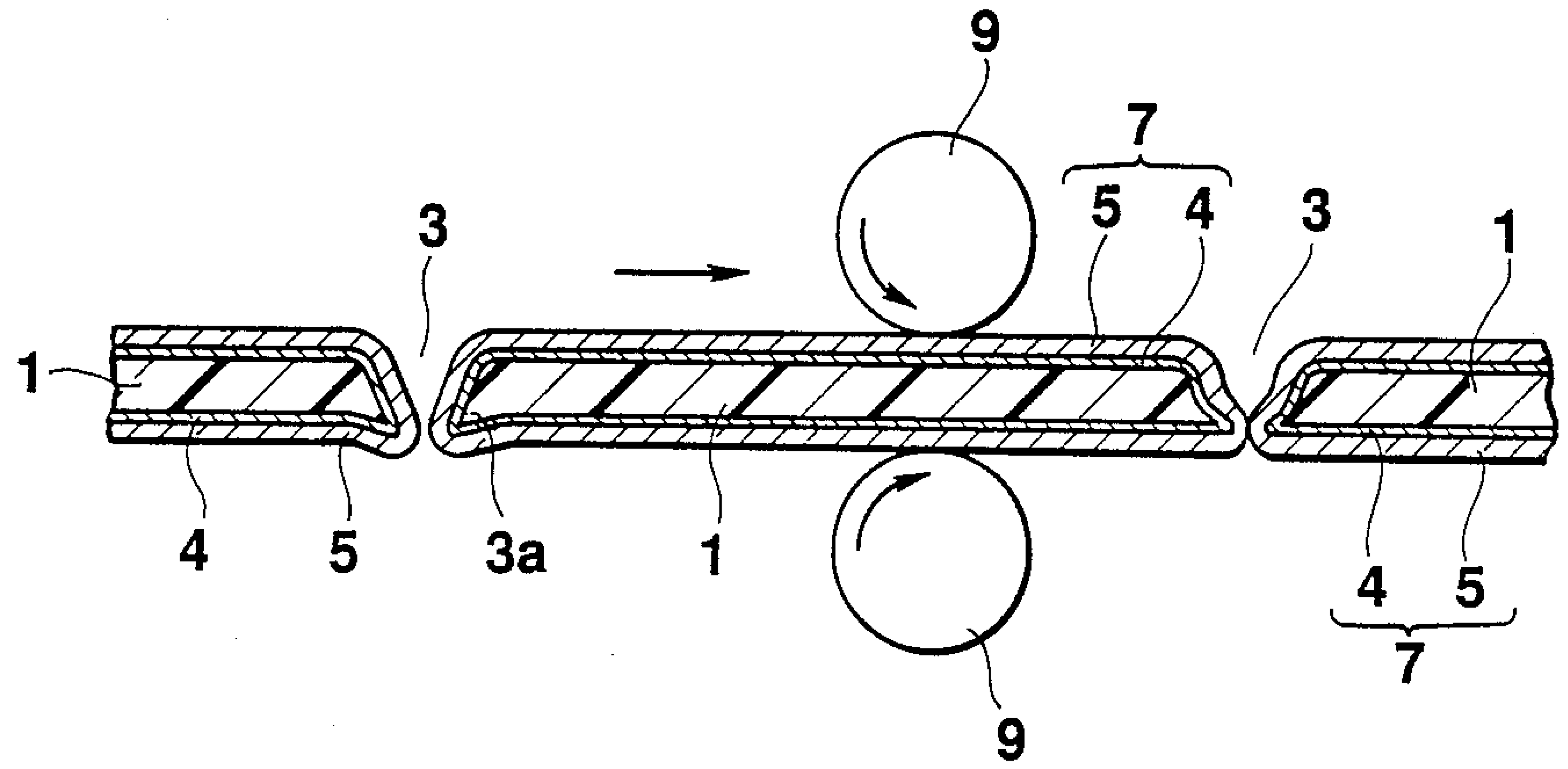


FIG.3

FIG. 4 A

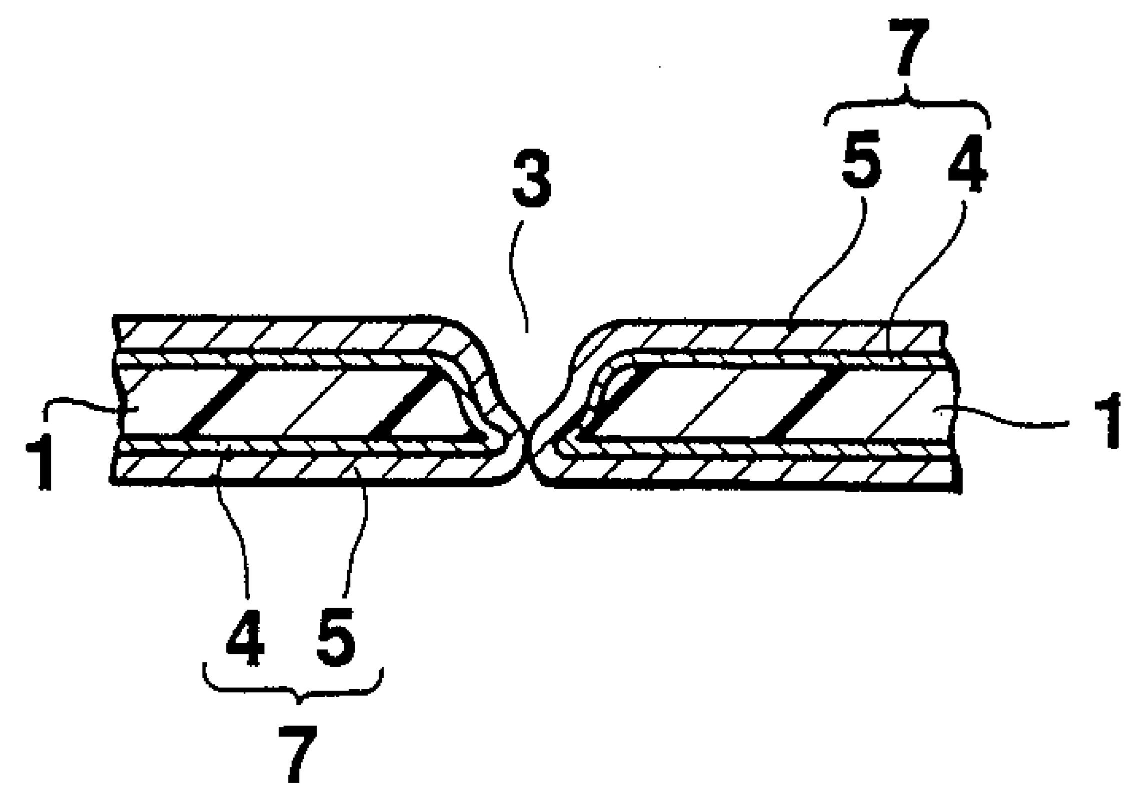


FIG. 4 B

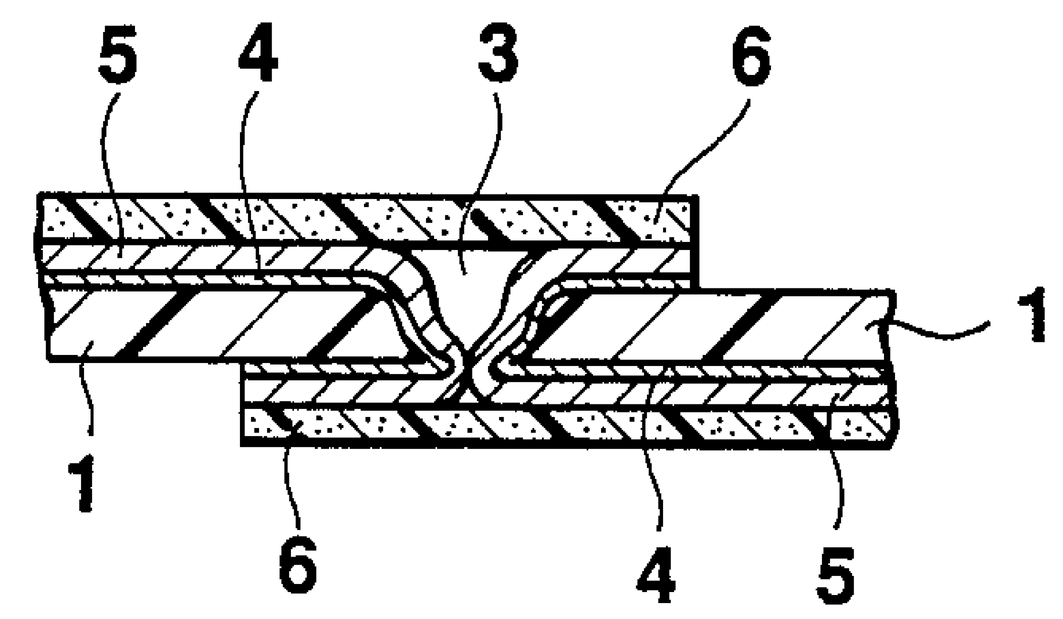


FIG. 4 C

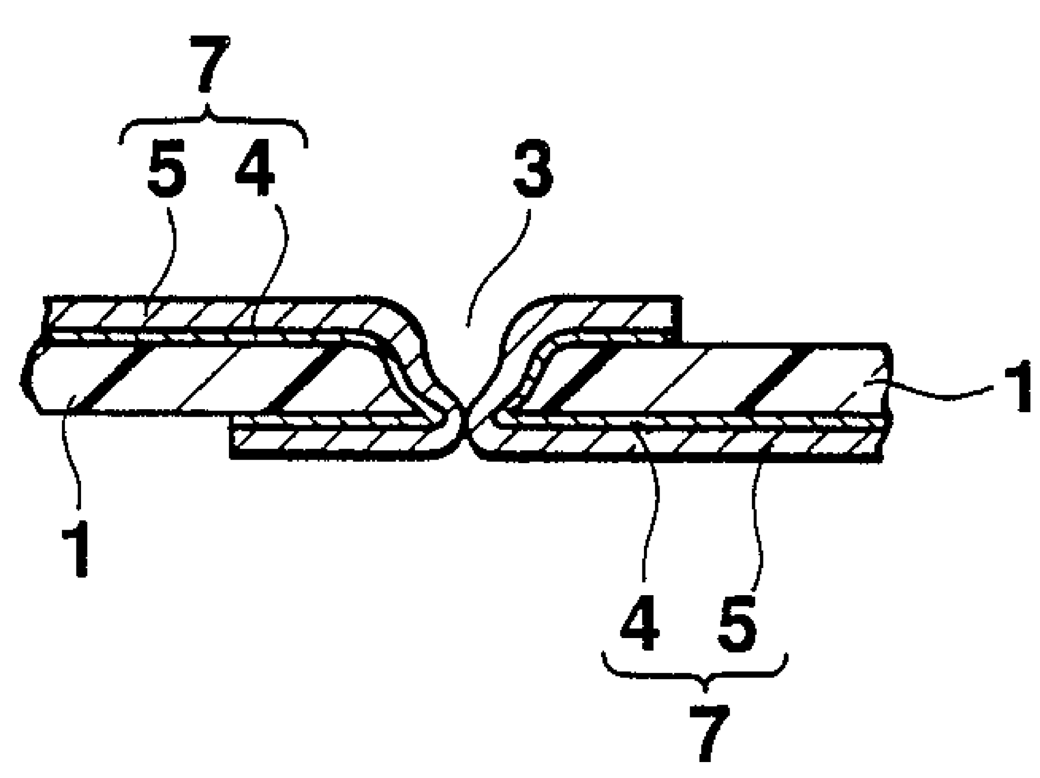


FIG. 5A

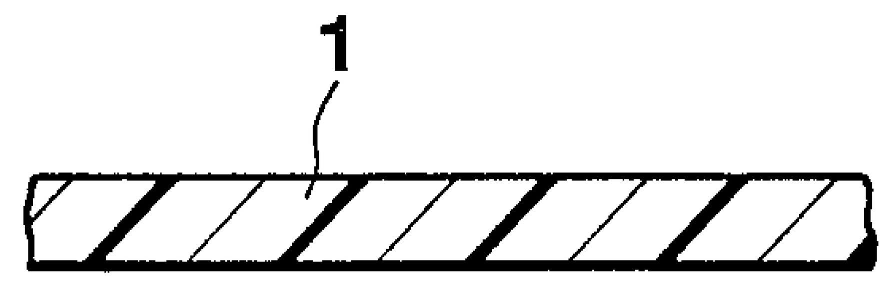


FIG. 5B

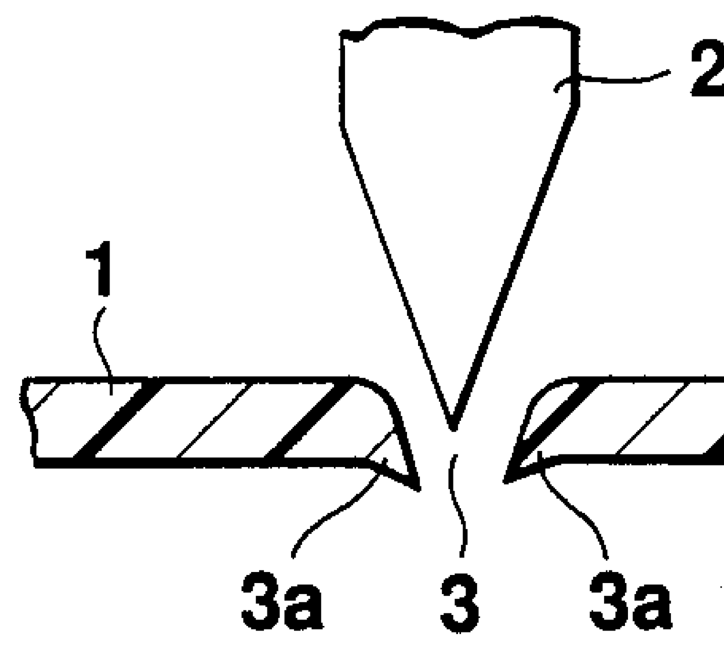


FIG. 5C

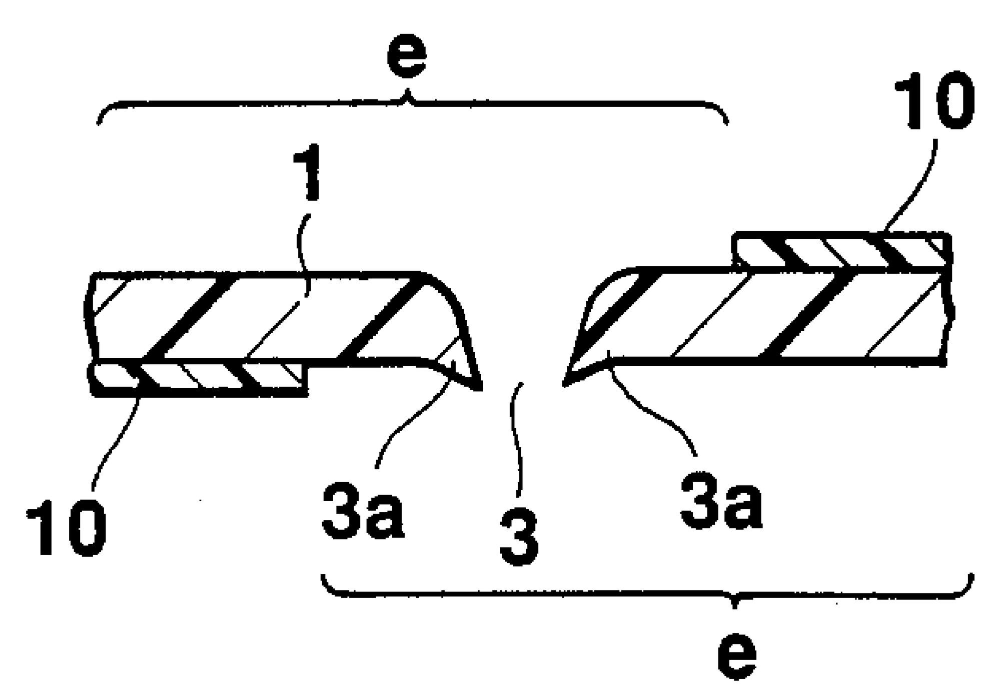


FIG. 5D

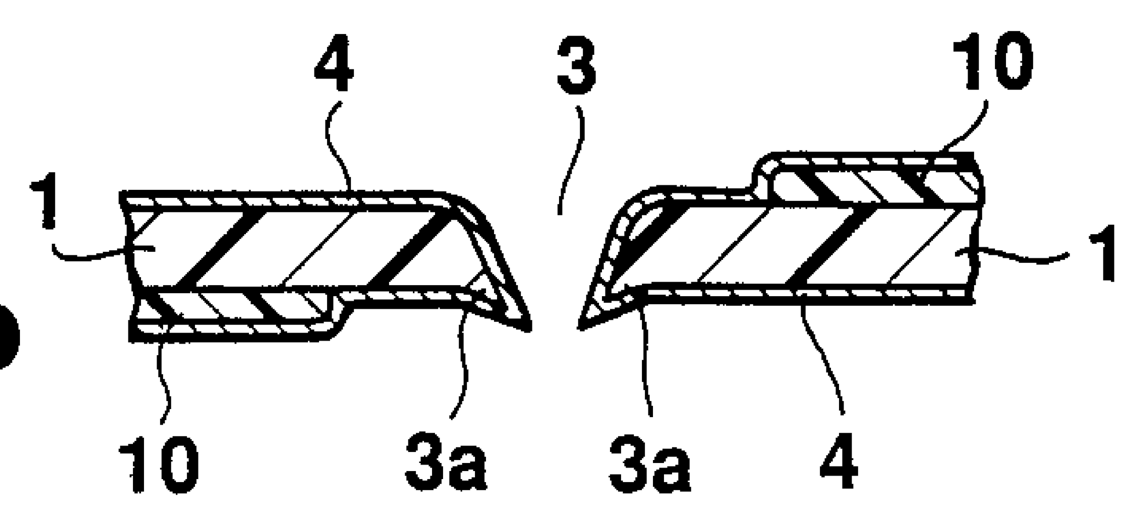


FIG. 5E

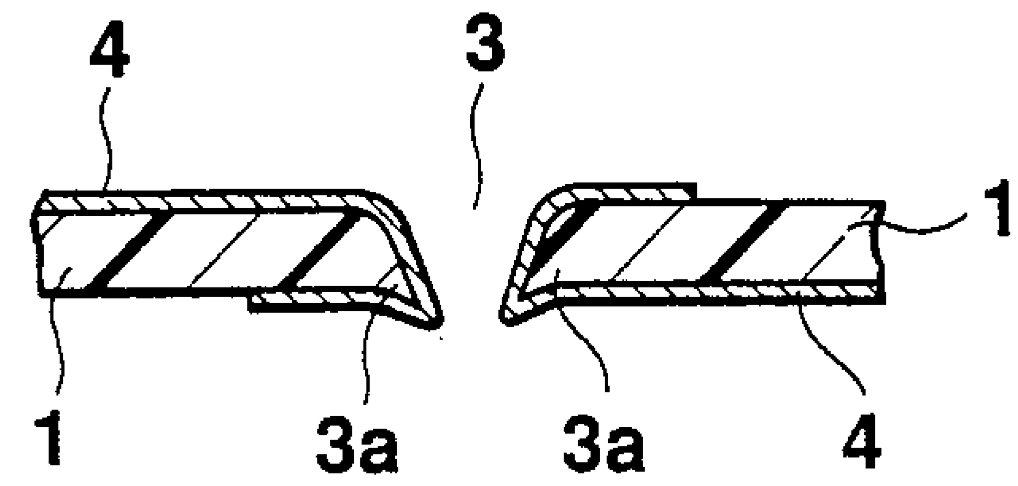


FIG. 5F

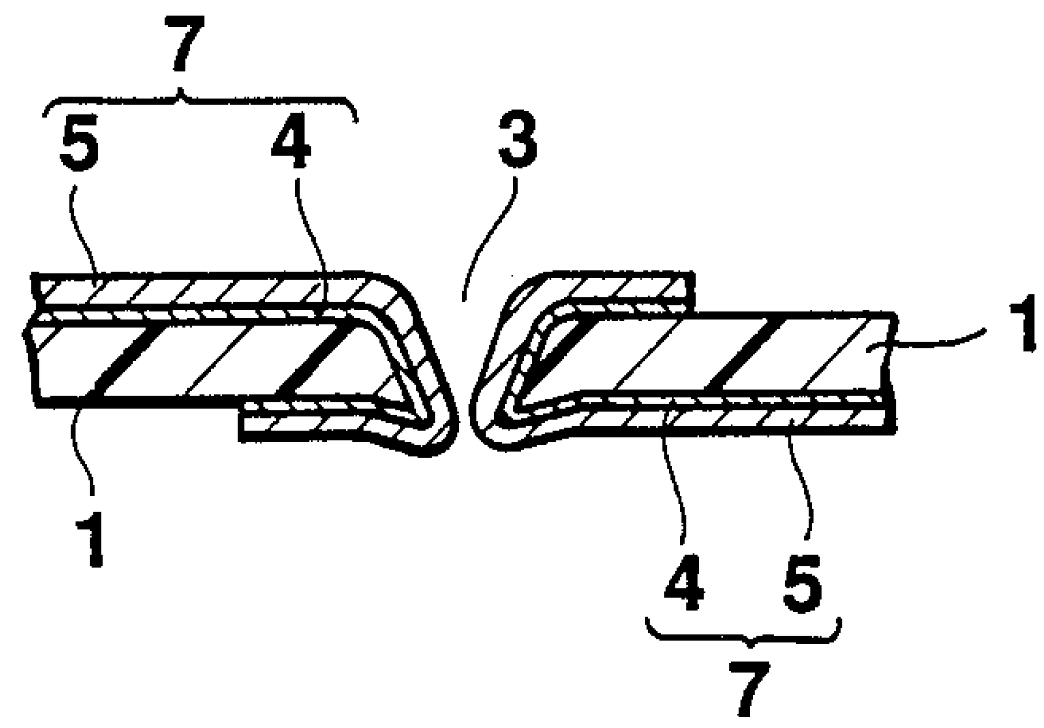
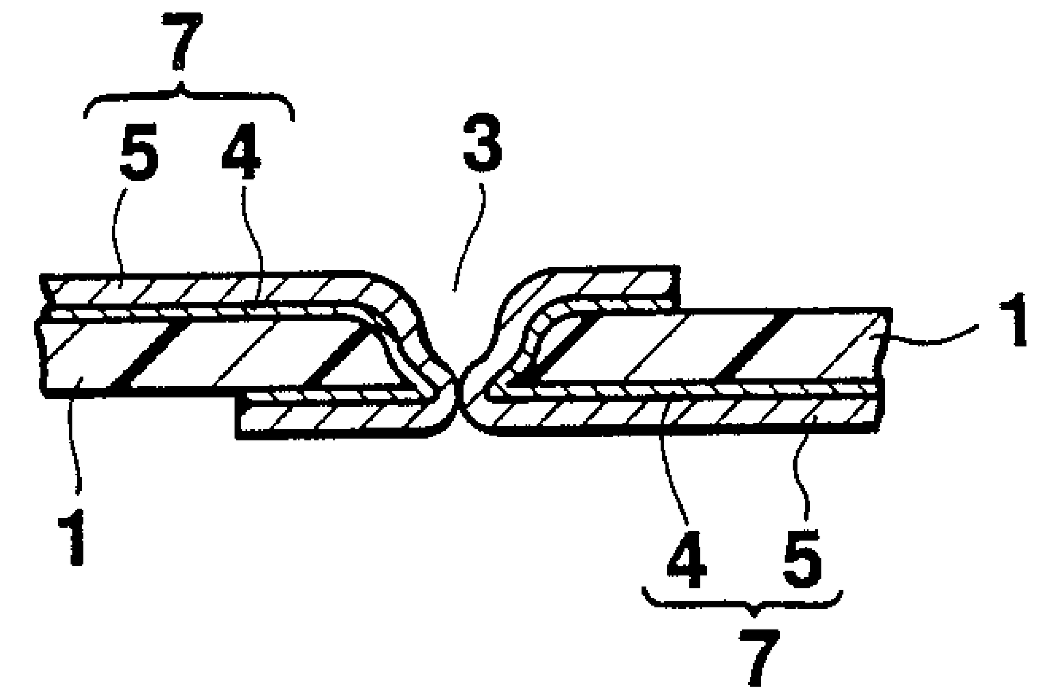


FIG. 5G



METHOD OF MANUFACTURING DOUBLE-SIDED WIRING SUBSTRATE

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to a method of manufacturing a double-sided wiring substrate and, more particularly, to a method of efficiently forming fine wiring patterns having a low resistance on both surfaces of a substrate.

2. Description of the Related Art

In a conventional double-sided wiring substrate having surfaces on both of which electric conductive patterns hereinafter wiring patterns are respectively formed, a through hole which extends from the upper surface to the lower surface of the substrate is formed by, e.g., punching or drilling, and a metal such as copper is plated on the inner wall of the through hole to connect the wiring patterns formed on both the surfaces. In such a method, however, a metal such as copper cannot be directly plated on the inner wall of the through hole, and hence a pretreatment or undercoating treatment must be performed in advance for the inner wall of the through hole. Therefore, the plating process is complicated, and manufacturing cost is undesirably increased.

Recently, the following method has been considered. That is, after a substrate is pierced with a metal pin to form a pin hole which extends from the upper surface to the lower surface, the pin hole is filled with an electric conductive paste to connect wiring patterns respectively formed on the upper and lower surfaces. The above technique is disclosed in Published Unexamined Japanese Patent Application Nos. 60-208888 and 60-208894.

In the technique disclosed in the above applications, a carbon ink is used as an electric conductive paste. Since the carbon ink has a high electric resistivity, it cannot be applied to a low-resistance circuit. In addition, as is conventionally known, when a conductive pattern is formed with the carbon ink, it may often be stained or blurred to disable formation of fine wiring patterns.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a method of manufacturing a double-sided wiring substrate which can form fine electric conductive patterns having a low resistance, and allows efficient manufacture.

In order to achieve the above object, according to the present invention, there is provided a method of manufacturing a double-sided substrate comprising the steps of:

forming a hole in an insulating film by a pin;

forming a thin metal film on upper and lower surfaces of the insulating film and an inner wall of the hole by deposition;

forming a thick metal film on the thin metal film by plating; and

etching a predetermined portion of the thin and thick metal films formed on the upper and lower surfaces of the insulating film to form a conductive patterns having a layered structure of the thin and thick metal films, the conductive patterns extending from the inner wall of the hole to the upper and lower surfaces of the insulating film.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1A** to **1H** are enlarged sectional views of a main part of a wiring substrate in each manufacturing step, and show a method of manufacturing a double-sided wiring substrate according to the first embodiment of the present invention;

FIGS. **2A** to **2H** are plan views respectively corresponding to FIGS. **1A** to **1H**;

FIG. **3** is a sectional view for explaining a method of removing burrs arisen at edges of the wiring substrate during the manufacture;

FIGS. **4A** to **4C** are enlarged sectional views of a main part of the wiring substrate for explaining the manufacturing steps after a treatment in FIG. **3**; and

FIGS. **5A** to **5G** are enlarged sectional views of a wiring substrate in each manufacturing step showing the second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(First Embodiment)

A method of manufacturing the present invention will be described hereinafter with reference to the accompanying drawings.

As shown in FIGS. **1A** and **2A**, an insulating film **1** is prepared. The insulating film **1** consists of a synthetic resin, e.g., polyimide, polyester or epoxy glass. As shown in FIGS. **1B** and **2B**, the insulating film **1** is pierced from its upper surface with a metal pin **2** to form a pin hole **3** which extends from the upper surface to the lower surface at a predetermined portion of the insulating film **1**. In this case, e.g., a cotton needle No. **5** (the diameter of a thickest portion: 0.84 mm) is used as the pin **2** to cause its sharp distal end to form a tapered hole having a mean hole diameter of 0.1 to 0.4 mm. Note the pin hole **3** is formed by the pin **2**, the insulating film **1** is directly pierced by the sharp distal end before a metal layer such as a copper layer is formed on the surface of the insulating film **1**. Therefore, the distal end of the pin **2** is scarcely rounded.

As shown in FIGS. **1C** and **2C**, a thin metal film **4** is formed on the upper and lower surfaces of the insulating film **1** and the inner wall of the pin hole **3** by vacuum deposition or sputtering. The thin metal film **4** consists of a metal such as copper (Cu) or aluminum (Al). The thickness of the thin metal film **4** is about several hundreds to several thousands Å. As described above, the pin hole **3** is tapered to be narrower toward its lower end. Therefore, when the thin metal film **4** is formed on the upper surface of the insulating film **1**, metal particles are also adhered to the inner wall of the pin hole **3**. Therefore, the thin metal film **4** is continuously formed to cover the upper and lower surfaces of the insulating film **1** through the pin hole **3**. In practice vacuum deposition or sputtering is performed twice, i.e., to the upper and lower surfaces of the insulating film **1**, as a matter of course. The thin metal film **4** is then adhered to the inner wall of the pin hole **3** in the two operations, thus realizing further reliable adhesion.

Thereafter, as shown in FIGS. **1D** and **2D**, a thick metal film **5** is formed on the entire surface of the thin metal film **4** by electroplating. The thick metal film **5** can be easily formed by electroplating because the thin metal film **4** serves as an undercoating electric plating layer. Although the material of the thick metal film **5** may be preferably the same as that of the thin metal film

4, it is not limited thereto. The thickness of the thick metal film 5 is about several to several tens μm. In this case, since the pin hole 3 is tapered to be narrower toward its lower end, metal particles can be successfully deposited to the thin metal film 4 formed on the inner wall of the pin hole 3, thus forming the thick metal film 5.

As shown in FIGS. 1E and 2E, a resist layer 6 is patterned on the surface of the thick metal film 5 formed on the upper and lower surfaces of the insulating film 1 by, e.g., a screen printing or a photolithography. In case the resist layer 6 is formed by a screen printing, a resist is printed on the thick metal film 5 through a screen to directly form a predetermined patterns of the resist layer 6 shown in FIG. 2E. In case the layer 6 is formed by a photolithography, the resist layer 6 is deposited on the entire surface of the insulating film 1, and a series of processing steps, i.e., masking, exposure, and developing are executed. Therefore, the predetermined patterns of the resist layer 6 shown in FIG. 2E is formed. A wet or dry resist film can be used as the resist in this case. However, the upper and lower regions of the pin hole 3 must be reliably covered with the resist layer 6.

Thereafter, as shown in FIGS. 1F and 2F, the thick and the thin metal films 5 and 4 are etched by an etching solution using the resist layer 6 as a mask. Etching may be performed once when the materials of the thick and the thin metal films 5 and 4 are the same. In case these materials are different from each other, etching must be performed twice using another etching solution, as needed.

As shown in FIGS. 1G and 2G, when the resist layer 6 is removed, a two-layered wiring patterns 7 consisting of the thick and thin metal films 5 and 4 is formed on the upper and lower surfaces of the insulating film 1. The wiring patterns 7 is also formed on the inner wall of the pin hole 3, as a matter of course. Therefore, a double-sided wiring substrate wherein the wiring patterns 7 formed on the upper and lower surfaces of the insulating film 1 are electrically connected to each other through the pin hole 3 can be obtained.

Thereafter, as shown in FIGS. 1H and 2H, an insulating film 8 is applied to the entire upper and lower surfaces of the insulating film 1 to cover the wiring patterns 7, thereby protecting the wiring patterns 7 and the thick and the thin metal films 5 and 4 in the pin hole 3 from corrosion.

In the above-mentioned method of manufacturing the double-sided wiring substrate, the pin hole 3 is formed prior to formation of the metal layer. Therefore, durability of a sharp distal end of the pin 2 is excellent to minimize a waste of time which occurs when the pin is exchanged. In addition, a resistivity of the thin and the thick metal films 4 and 5 is low, and these films can be efficiently formed. Furthermore, since the resist layer 6 and the wiring patterns 7 can be formed by a photolithography, extremely fine wiring can be effectively realized.

Note that, in the above embodiment, when the pin hole 3 is formed in the insulating film 1 by the pin 2, burrs 3a is formed at the lower end periphery of the pin hole 3 through which the pin 2 extends. Burrs 3a extends from the surface of the insulating film 1. Therefore, in the following step, i.e., the step of depositing a resist shown in FIG. 1E, a mask or screen member may float from the surface, and may not be brought into tight contact with the surface of the film 1.

FIG. 3 is a sectional view showing a processing step performed to solve the above problem. As shown in FIG. ID, after the thin and the thick metal films 4 and 5 are formed on the inner wall of the pin hole 3 and the upper and lower surfaces of the insulating film 1, the insulating film 1 is sandwiched by a pair of upper and lower rollers 9 and is rolled, as shown in FIG. 3. Although rolling in this case is performed at a normal temperature, the insulating film 1 may be heated upon rolling. Thus, when the insulating film 1 is rolled, burrs 3a and the metal layer 7 on the surface are pushed into the pin hole 3, and are plastically deformed. Therefore, the periphery of the pin hole 3 on the lower surface side is smoothed to flatten the surface of the insulating film 1 and the metal layer 7, as shown in FIG. 4A.

For this reason, as shown in FIGS. 4B and 4C, resist formation and etching of the wiring patterns can be accurately performed.

(Second Embodiment)

The second embodiment of the present invention will be described hereinafter with reference to FIGS. 5A to 5G.

FIGS. 5A and 5B correspond to FIGS. 1A and 1B, respectively. Since the steps in FIGS. 5A and 5B have been described in the first embodiment, a description thereof will be omitted.

After a pin hole 3 is formed in an insulating film 1 by a pin 2, an insulating layer 10 is formed on the entire region on the upper and lower surfaces of the insulating film 1 except for a wiring pattern formation region e by a screen printing or a photolithography, as shown in FIG. 5C. The insulating layer 10 consists of a hot melt resin or a resist such as a photoresist. In case the insulating layer 10 is formed by a screen printing, a resist is printed on the insulating film 1 through a screen to form the insulating layer 10. In case the insulating layer 10 is formed by a photolithography, a photoresist is applied to the entire surface of the insulating film 1, and the photoresist is exposed and developed through a mask, thereby patterning the insulating layer 10.

Subsequently, as shown in FIG. 5D, a thin metal film 4 is formed on the upper and lower surfaces of the insulating film 1 including the above-mentioned insulating layer 10, and the inner wall of the pin hole 3 by vacuum deposition or sputtering. The thin metal film 4 is also formed on burrs 3a arisen at the periphery of the pin hole 3 on the lower surface side.

As shown in FIG. 5E, the insulating layer 10 is peeled to remove the thin metal film 4 formed on the region except for the wiring pattern formation region e. More specifically, when the insulating layer 10 is peeled, the insulating layer 10 is heated and melted or etched to be removed. When the insulating layer 10 is etched, an edge or a part of the thin metal film 4 on the insulating film 10 is removed in advance. Thus, when the insulating layer 10 is removed, unnecessary portions of the thin metal film 4 are removed upon removal of the layer 10, and the thin metal film 4 is left in only the wiring pattern formation region e.

Thereafter, as shown in FIG. 5F, a thick metal film 5 is formed on the entire surface of the thin metal film 4 by electroplating. The thick metal film 5 can be easily formed on only the surface of the thin metal film 4 by electroplating because the thin metal film 4 serves as an undercoating electroplating layer. However, the metal thick film 5 is not formed on a region of the insulating film 1 from which the insulating layer 10 is peeled.

Thus, wiring patterns **7** electrically connected to each other through the pin hole **3** are formed on the upper and lower surfaces of the insulating film **1**.

In the next step shown in FIG. **5G**, burrs **3***a* formed on the lower surface side of the pin hole **3** is rolled and is pushed into the pin hole **3** to flatten the surface. In this case, in the same manner as in the first embodiment, as shown in FIG. **3**, the insulating film **1** is sandwiched by a pair of upper and lower rollers **9**, and is rolled. Although rolling in this case is also performed at a normal temperature, the insulating film **1** may be heated upon rolling. Thus, when the insulating film **1** is rolled, the burrs **3***a* and the wiring patterns **7** are pushed into the pin hole **3**. Therefore, the periphery of the pin hole **3** on the lower surface side is smoothed to flatten the surface of the insulating film **1** and the metal layer **7**.

Thereafter, the entire surface may be covered with a protective film, if necessary.

Note that the present invention is not limited to the above embodiments, and various changes and modifications can be made. For example, in the above embodiments, the thin and the thick metal films **4** and **5** are dipped into an etching solution and are etched. However, unnecessary portions of the thin and the thick metal films **4** and **5** may be removed by dry etching such as reactive ion etching using a reactive gas. If, e.g., solder or gold (Au) which hardly corrode is used as a metal material for the thick metal film **5**, the insulating film **8** for protection is not necessary. In addition, the thin metal film **4** need not always have a one-layered structure, and a multi-layered structure may be achieved. The number of pin holes **3** is not limited to one, and a plurality of pin holes may be formed to improve reliability of connection. Note that the insulating film may be surface-treated, or a proper coating material may be applied to the insulating film. A plurality of laminated insulating films can be used. In addition, the double-sided wiring substrate in this invention is not limited to the above-described embodiments. For example, a wiring substrate wherein only a wiring pattern, for connecting substrates to each other, for connecting a substrate to an electric part, or for connecting electric parts to each other, is formed, i.e., a so-called flexible connector, is included in the double-sided wiring substrate in the present invention.

What is claimed is:

1. A method of manufacturing a double-sided wiring substrate comprising the steps of:

forming a hole in an insulating film by a pin;

forming a thin metal film on upper and lower surfaces of said insulating film and an inner wall of the hole by deposition;

forming a thick metal film on said thin metal film by plating; and

etching a predetermined portion of said thin and thick metal films formed on said upper and lower surfaces of said insulating film to form a conductive patterns having a layered structure of said thin and thick metal films, said conductive patterns extending from said inner wall of the hoe to said upper and lower surfaces of said insulating film.

2. A method of manufacturing a double-sided wiring substrate comprising the steps of:

forming a hole in an insulating film by a pin;

forming a thin metal film on upper and lower surfaces of said insulating film and an inner wall of the hole by deposition;

forming a thick metal film on said thin metal film by plating;

covering a portion of said thick metal film formed on said upper and lower surfaces of said insulating film and said thin metal film formed on said inner wall of the hole with an etching resist; and

etching portions of said thick and thin metal films which are not covered with said etching resist.

3. A method according to claim **2**, further comprising the step of rolling said thick metal film formed on a periphery of the pin hole inside the hole after said thick metal film is formed.

4. A method of manufacturing a double-sided wiring substrate comprising the steps of:

forming a hole in an insulating film by a pin;

forming a resist, having a shape which is complementary with a wiring patterns to be formed, on upper and lower surfaces of said insulating film;

forming a thin metal film on said resist and said insulating film including an inner wall of the hole by deposition;

removing said resist from said insulating film and eliminating a portion of said metal thin film formed on said resist at the same time; and

forming a thick metal film on a portion of said thin metal film left on said insulating film by plating.

5. A method according to claim **4**, further comprising the step of rolling said thick metal film formed on a periphery of the hole inside the hole.

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